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SIXTH ANNUAL REPORT

PRIEST RIVER EXPERIMENT STATION

For The Year 1916.

SIXTH ANNUAL REPORT

PRIEST RIVER EXPERIMENT STATION

For the Year 1916.

PART I.

ADMINISTRATION.

	Page
I. Organization, ...	1.
II. Investigative Progress, ...	2.
III. The Experimental Forest, ...	4.
IV. Improvements & Maintenance, ...	4.
V. Equipment, ...	6.
VI. Future Work, ...	6.
VII. Budget, ...	7.

PART II.

INVESTIGATIVE PROGRESS AND RESULTS.

SIXTH ANNUAL REPORT

Priest River Forest Experiment Station.

Season 1916.

PART ONE

I. Organization:

At the close of the fifth year in the history of the Experiment Station we find further changes in the organization. For the sake of closer mutual cooperation between the investigative organization and the man engaged on closely related administrative lines, such as planting, marking and timber appraisals, Forest Examiner Brewster's headquarters was temporarily changed to Missoula at the end of the year with a possibility that it may be made permanent. The tendency during the last two years has been for Brewster to specialize on the management and tree studies which are District wide and which can be carried out more effectually with headquarters at Missoula.

Coincident with this change the amount of the clerical work at the Station was greatly reduced so that the volume of the office work did not warrant a year-long Forest clerk. Lee Straton was therefore transferred to administrative work on the Missoula National Forest, and Ranger W. P.

Hillman has been assigned to cover a wider field of activities than was possible by a Forest clerk.

The following Field Assistants have been employed:

T. S. Hansen, mainly with Brewster, from the beginning of the year until September.

R. R. Lyman and H. K. Harriman, with Brewster on management and tree studies during September and October.

W. D. Richardson, with Larsen from September until December.

Thus the year 1917 starts out with the following organization:

Forest Examiner D. R. Brewster at Missoula, specializing on Management and Tree Studies; Forest Examiner J. A. Larsen conducting the experiments at the Station which consist of the completion of the forestation projects and the necessary reports, seed testing, type study, volume growth and yield studies on the Experimental Forest, periodic counts and measurements of plantations and permanent sample plots and miscellaneous work in connection with experiments under way; Forest Ranger W. P. Hillman in charge of development maintenance and miscellaneous administrative work connected with the Experimental Forest, and the upkeep of the Station plant.

II. Investigative Progress:

Work has been continued on the studies in source of

seed, seed extraction, the stimulation of white pine seed to secure greater and more rapid germination, and the studies on longevity of white pine seed stored in the duff. No new field work has been done on the nursery studies since the work on these has been completed, but the material has been assembled for final reports which are now in preparation. Several species of exotic hardwoods have been planted in the field and counts and measurements have been continued on all plots in the various reforestation experiments not concluded in 1915. Particular attention was paid to experiments in classes of stock with both western yellow pine and western white pine.

The data for the four years of the five year daily observations in the type study at the four meteorological stations has been assembled, summarized and analyzed. On the basis of this, it was possible to say what progress had been made in this study and to determine to close the first phase of this project and discontinue the readings at the outlying stations at the end of the 1916 growing season.

Final counts and measurements were made of all seedlings in the study of natural reproduction and practically all of this material has been worked up preparatory to a final report and for use in connection with the meteorological study of forest types and western larch tree study.

Five permanent sample plots for the study of growth and yield were installed on the Experimental Forest this fall,

and observations were made in seed production on the 1914 series of thinning plots.

An extensive girdling experiment with 100 trees of western hemlock and white fir was started involving girdling of new trees each month and close observations on the trees girdled in each previous series.

III. Experimental Forest:

In order to relieve the investigative organization of the extra burden of the protective administration and development of the Experimental Forest, the responsibility for this was transferred to the Supervisor of the Kaniksu National Forest. This change was affected after due consideration by all parties concerned. The absorption of this work by the Kaniksu National Forest organization whereby it becomes an integral part of their fire protection scheme was a logical step, and the further taking over of all administrative responsibility for the Station plant has greatly reduced the work of the investigative force and made it possible to accomplish much more along strictly investigative lines

A trail plan has been prepared covering a complete system of trails for the area.

IV. Improvements and Maintenance.

About four miles of new trail was constructed, thereby practically completing the main trunk trail from the

Station to one of the chief lookout stations in the valley, serving both the Kaniksu National Forest and the Experiment Station. This trail has a maximum of 15 percent grade and is much shorter than the old route. One quarter mile of much needed wagon road used for entrance to the Station from the main county road was put in permanent shape by stumping and grading.

Two buildings for the Ranger conference and other uses, one bunk house and one lecture hall and drafting room have been constructed during the year. A saving in space and material was effected by combining the latter building, with a much needed wood shed and ice house for the three cottages.

The Benton Ranger Station and the newly built bunk house were painted during the summer and a coat of stain and roof paint was given cottage 3, the lecture hall and the wagon shed.

Additional ground was stumped around the dwellings in the spring and a substantial woven wire fence constructed around the quarters to shut off stock. The construction of the fence made it possible to assign definite playground and yard space adjoining each dwelling and to put up clothes lines in each yard.

Cottages 1 and 2 have been papered to provide warmer quarters and material is now on hand for felting and papering the office rooms.

Six hundred feet of 2-inch wooden pipe line was laid to the Benton Flat Nursery and four hundred feet to the Ranger bunk house. All brush was dug up and cleared away from the Benton Flat planting site.

V. Equipment:

Important additions to the experimental equipment during the year were as follows:

1. An airmeter for the accurate measurement of wind velocity for short periods of time.
2. Five Livingston porous cup atmometers with non-absorbing mountings for evaporation studies.
3. One Friez soil thermograph, especially adapted for use in the country-wide soil temperature survey.
4. One hygrometer.
5. Two germinating pans, fitted up with special glass covers, knitted discs, wicks, and funnels on the principle of the Jacobsen apparatus used in Denmark.

VI. The Future Investigative Work at the Experiment Station.

The end of the fifth year brings us also to the completion of many reforestation studies, which were started when the Station was established. Important seed, nursery and planting studies will still continue to be a part of the Station's work, but to a much lesser extent than in the past, and directed to the solution of such problems as require close

Observations and control, supplemented by laboratory methods. In the main however the trend now is toward the solution of problems which deal with the life history, growth and physiological characteristics of the species and stands and their relation to the environment. These will require long-time field experiments as well as close laboratory work.

Thorough and complete work along these lines can only be carried on at a well equipped and properly located permanent field stations such as the Priest River Experiment Station, and the adjoining Forest, which is made more accessible from year to year by the completion of new trails. Thus the growth in the scope of the work keeps pace with the development and rounding out in experience and training of the personnel.

VII Business Statement:

(1) Fiscal Year 1917.

The distribution of the Experiment Station funds and the total allotments for the fiscal year 1917 are shown in the following summary:

A. Silvical Investigations Schedule:

<u>Item</u>	<u>Salary</u>	<u>Travel</u>	<u>Subsist. & Misc.</u>	<u>Total</u>
D. R. Brewster,	\$1,800.00	\$400.00	-----	\$2,200.00
T. S. Hansen,	1,100.00	300.00	-----	1,400.00
Field Assistant, Exp. Sta.	375.00	-----	100.00	475.00
Temporary Labor,	500.00	-----	-----	500.00
Experimental Sup. & Equip.	-----	-----	150.00	150.00
Freight, hauling & Office	-----	-----	25.00	25.00
Subsistence,	-----	-----	100.00	100.00
Total for "S.I." allotted direct to Exp. Sta.				\$4,850.00
C. N. Whitner, (allotted to (Deerlodge N.F. 6 months)	750.00	-----	-----	750.00
Total from "S. I." for all Forest Investigations,				\$5,600.00

B. General Expense Schedule:

<u>Item</u>	<u>Salary</u>	<u>Misc.</u>	<u>Total</u>
Asst. Forest Ranger, (Statutory)	\$1,100.00	-----	\$1,100.00
J. A. Larsen (6 mos.)	700.00	-----	700.00
Supplies & Equipment,	-----	\$150.00	150.00
Maintenance of Gov't horses,	-----	200.00	200.00
Total,			\$2,150.00

C. National Forest Planting Schedule:

<u>Item</u>	<u>Salary</u>	<u>Misc.</u>	<u>Total</u>
J. A. Larsen, (6 mos.)	\$700.00	-----	\$700.00

D. Improvement Schedule:

<u>Item</u>	<u>Total</u>
Maintenance of buildings, roads and trails on Expt. Sta. Forest,	\$1,000.00
Total,	\$1,000.00

E. Statutory Position:

Forest Clerk, Lee Stratton,

\$1,300.00

RECAPITULATION

Total Silvical Investigations,	\$5,600.00
" General Expense,	2,150.00
" National Forest Planting,	700.00
" Improvement Schedule,	1,000.00
" Statutory Position,	<u>1,300.00</u>
Total,	\$10,750.00

(2) Fiscal Year 1918.

The funds needed for the Experimental Station for the fiscal year 1918 will be as follows:

<u>Schedule</u>	<u>Purpose</u>	<u>Amount</u>	<u>Total</u>
<u>Silvical Investi-</u>	Salary, J.A. Larsen	\$1,400.00	
<u>gations,</u>	Temporary Assistants	300.00	
	Travel,	200.00	
	Supplies & Equip.	150.00	
	Misc. Expenses,	<u>50.00</u>	
			\$2,100.00

<u>Schedule</u>	<u>Purpose</u>	<u>Amount</u>	
<u>General Expense.</u>	Improvement and		
	Maintenance,	\$200.00	
	Imp. New Construction,	800.00	
	Horse Feed,	200.00	
	Supplies & Equip.	100.00	
	Temporary Labor on		
	Fuel and other		
	current work,	<u>300.00</u>	
			\$1,600.00

Statutory Roll.

W. P. Hillman,		
Ranger at Exp. Sta.	\$1,200.00	\$1,200.00

RECAPITULATION.

Silvical Investigations,	\$2,100.00
General Expenses,	1,600.00
Statutory Roll,	<u>1,200.00</u>
Total,	\$4,900.00

SIXTH ANNUAL REPORT

PRIEST RIVER EXPERIMENT STATION.

Year 1916.

P A R T II.

INVESTIGATIVE PROGRESS AND RESULTS.

RS
F. D-1,
P. R. E. S.

December 30, 1916.

Five Years of Progress in Forestation Studies

Priest River Experiment Station.

District One.

The Need of Forestation Investigations.

Prior to the establishment of the Priest River Experiment Station in the fall of 1911, the reforestation work of the District was in an uncertain and more or less embryonic condition. Thousands of dollars were being spent each year in planting and sowing a considerable acreage in all parts of the District. Results were not dependable and included a considerable percentage of complete or partial failures. The need of detailed investigative work which would furnish more exact information on correct methods to use was strongly felt.

In nursery practice, methods based on those used in eastern nurseries but poorly adapted to local conditions were being used. Large losses were frequent but apparently unavoidable, and all the operations were on a hit-or-miss, guess-work basis. Costs of stock were high and the plants were often not of good quality or suitable for field planting. This led to heavy losses and failures in field plantations and raised the cost of planting work per effective acre

to a very high figure.

The seed policy was governed by uncertainty and lack of knowledge. Because costs of collection and extraction were considerably cheaper than in previous operations on the different Forests in District One, thousands of pounds of yellow pine seed from the Black Hills Forest in District Two were used in nursery and sowing operations in the District in 1910. The seed was so much smaller than previous seed used in the nurseries that when the beds were sown by the rough rule of thumb, then in use, of using so many pounds per bed, the resulting stand was so excessively dense that the seedlings produced were so slender and poorly developed as to be of small value for field planting. Large losses occurred in the transplant beds and plantations from the use of such stock. The use on the Forests of this District of seed from such a distinctly different climatic region as the Black Hills is furthermore decidedly questionable. The burden of proof should have been placed on this seed to show, in an experimental way, that it was suited to our needs before large quantities were used, as the difference in first cost was unimportant compared to the possible total loss of plantations which might result from using seed unsuited to the climate of the locality where used.

Field planting had been recognized as being in more or less of an experimental stage, and a large part of the sowing and planting work that had been done had been considered

experimental in nature and purpose. These experiments were, however, not properly correlated nor planned so as to bring out clearly and certainly the best methods to follow. They were furthermore on such a large scale, in the attempt to make them of some commercial importance, that the care necessary to give them value for investigative purposes could not be used in installations and the making of observations and the original experimental purpose was largely or entirely defeated. Results were consequently disappointing and inconclusive, and not commensurate with the amount of time and money expended. It was felt that in consideration of the considerable investment in reforestation being made in the District each year, steps should be taken to replace uncertainties with certainties and put the work on a successful basis as soon as possible by means of careful, scientific investigations.

General Survey of the Work:

Reforestation problems were the most prominent and urgent work for the Experiment Station to undertake. Many different phases of the subject were in need of immediate investigation and it was difficult to know where to begin. Consequently all of the more obvious problems were placed on the program at the start. This comprehensive initial program possibly tended to diffuse the efforts of the limited force over too wide a field. It was, however, impossible to predict just how large a program could be carried to best

advantage. The inclusion of all the important phases at the beginning served a good purpose in encouraging the making of some progress all along the line. This progress has yielded more or less information for immediate practical application on all the important problems involved, and will form a valuable foundation of experience for the work of verification and amplification which will be conducted in the future.

During the seasons of 1912 and 1913, forestation studies were confined to the Experiment Station. Progress was hampered by limited facilities for planting work and by the difficulty and expense of building up an experimental nursery sufficiently large for thorough work. Because of these limitations it was decided in 1914 to transfer at least part of the nursery and planting work to the Savenac Nursery and an experimental planting area at Placer Creek on the Coeur d'Alene Forest, representative of the large 1910 burns awaiting reforestation on that and neighboring Forests. The results to be obtained from many of the experiments were recognized to be of greatest practical value for local application, and it was felt that they should therefore be carried on where the results were to be applied and where best facilities could be provided for conducting the work.

The wisdom of moving the base of operations in

this way has been clearly shown by the excellent results obtained at Savenac and Placer Creek in 1914, 1915 and 1916, made possible by the earlier experience at the Experiment Station, the admirable facilities available for carrying on the work, and the close cooperation and assistance rendered by the administrative officers engaged in planting work.

Since 1914 the amount of new work started at the Experiment Station has been limited to the minimum considered necessary to bring the work already started to a conclusion, and to carry on the comparatively small number of studies which it was felt could still be conducted to better advantage at Priest River than elsewhere. The end of the 1916 season finds the field work completed on a majority of the studies and sufficiently far along on the others to permit of drawing fairly definite conclusions. With the work in this advanced stage, it is thought to be a logical time to prepare a condensed summary of the results of the work to date as given in the following pages:

1. Seed Studies:

The eleven seed studies on the Station program will be discussed under the following sub-project heads:-

Sect. (a). Seed Extraction.

The studies of western white pine and western yellow pine seed extraction, which involved chiefly a determination of the effect on the seed of different temperatures and degrees

of humidity in extraction, were conducted by J. E. Keach on the Kaniksu and St. Joe Forests in 1912 and 1913, under the supervision of the Section of Planting. The germination tests were made at the Experiment Station, being completed in 1914.

The tests of these experiments when taken in connection with a considerable number of others have indicated conclusively that white pine and yellow pine seed should not be subjected to extracting temperatures above 120° F. and that whenever possible drying of cones should be done largely or entirely in the open air in storage bins, without artificial heat.

Extraction at low temperatures and with partial or complete drying in the open air, based on these tests, has been used in all District operations since 1914, and has been accompanied by a notable improvement in the quality of the seed obtained. This in turn had led to better results and lower costs at the nursery, and has meant a saving of several thousand dollars altogether in a reduction in the amount of seed needed and a decrease in nursery costs.

Tests have also shown that it is injurious to allow white pine seed to remain for any great length of time in the wet or damp cones obtained from squirrel caches. This is apparently one of the principal causes of the delay in germination of the seed which has been a serious problem in nursery

practice in the past.

Over-winter storage in wet cones is estimated to have reduced the germination of the white pine seed collected in the fall of 1911 from a possible 75%, which might have been obtained if the cones had been extracted immediately, to 15% actually obtained from this seed. This meant a 500 percent increase in the cost of good seed per pound, or an increase of from \$2.50 to \$12.50 per pound, and a loss amounting to several hundred dollars in increased costs of nursery work due to poor seed and delayed germination. It also resulted in the production in 1913 and 1914 of only a fraction of the quantity of white pine stock required by the District planting schedule.

Since sufficient dry weather does not occur in the white pine region in the fall to dry the cones by natural means it has been the custom during the past two years to do the extracting during the late winter, spring and summer, using steam heat to some extent. Owing to injury to the seed, due to this long period of storage in the cones, as strongly indicated by recent tests, it is strongly recommended that special efforts be made to do all white pine extracting by artificial heat at low temperatures as soon after the cones are collected as possible. Preliminary drying and storage sheds should be used in connection with the artificial

heat, in order to obtain superficial and partial drying while the cones are awaiting extraction. It is felt that a considerable investment in suitable extracting facilities will be justified in order to obtain prompt drying of cones and extraction of seed. Reasonable promptness is also desirable with other species but is not difficult to obtain because of the smaller quantities of cones involved, the greater ease of extraction, and the fact that the cones do not absorb and hold moisture to the same extent as in the case of white pine.

Nothing has been done on the seed extraction of western larch because of the difficulty of obtaining cones. The study has been dropped from the program because of its comparative unimportance, but can be taken up later if thought desirable. A final report on the white pine and yellow pine studies will be completed during the present winter, and no further work is planned along this line.

Sect. (b). Comparative Germination in the Greenhouse and Nursery.

This study is important in providing a reliable guide as to the amount of seed to sow in the nursery beds to obtain within close limits the density of the stand desired. Seedlings grown too densely produce thin, poorly developed stock, unsuited to field planting, and a large amount of culling is necessary when such stock is grown. On the other hand, when the stand in the seed beds is not reasonably dense

the stock produced is apt to be over-developed, causing additional expense in handling, and the nursery space is not utilized to the fullest extent.

The investigative work on this project consists of:

(1) Germination tests in the Experiment Station greenhouse.

(2) Germination tests of the same seed in nursery beds.

The study has been conducted for five seasons, commencing in 1912. In 1913 and 1914 nursery tests were made at Priest River, Savenac and Boulder Nurseries. In 1915 they were confined to Priest River and Savenac and in 1916 it was decided to limit the nursery tests for that year and in the future to the Savenac Nursery, since the application of results will be confined entirely to the latter place.

The essential contribution which the Experiment Station has made to this study has been the perfection of reliable methods of testing seed in the greenhouse. It was necessary to standardize the methods of testing in order to make comparative germination studies of practicable value, and to provide a reliable and uniform basis of comparison with the nursery tests. Standard methods could only be prescribed after it was discovered under what conditions each species germinated best. It has, therefore, been necessary during the past four years to experiment with different media,

temperatures, etc., in order to discover the best methods of obtaining germination. This work is now completed and standard methods have been worked out for all species native to District One that are of any importance in nursery work.

One of the most valuable results of the experiments in seed testing methods has been the development of a standard apparatus built on the same principle as the Jacobsen apparatus used by the Danish Seed Control Station. In this apparatus the seed rests on filter paper under a closed bell jar in very moist air. The advantage of the Jacobsen apparatus over the method of testing seed in sand is that it preserves more uniform conditions of moisture and atmospheric humidity and allows of reproducing exactly the same conditions for an indefinite number of successive tests in different years. This is impossible with the tests made in sand. Germination is also more rapid and generally higher than in the sand.

The tests that have been made in this study have consistently shown that native seed gave a higher percentage of germination than did seed from other localities. That is, seed from Lolo Forest germinated best at Savenac, and seed from the Kaniksu Forest germinated best at Priest River. Other interesting points in regard to germination have been brought out by the study, which will be shown in the progress report to be prepared during the present winter.

Seed tests in connection with this study will continue

to be made at the Experiment Station greenhouse, but no further nursery tests are planned.

Sect. (c). Seed Production.

A study of seed production of western white pine was undertaken in the fall of 1911 in cooperation with Mr. Raphael Zon. Three plots of one-half acre each were laid off in neighboring stands of different age on the Kaniksu Forest and the cones were collected from certain representative trees and seed extracted. Various measurements and other data regarding the trees on the plot, the cones and the seeds were obtained and tabulated and all data forwarded to Mr. Zon. Germination tests were made in Washington and the material was published in the form of a bulletin in 1914.

The data obtained in this study has proven, during the past two years, to be of great practicable value in connection with the management studies in the white pine type. The figures obtained have been combined with those obtained later in the study of source of seed of white pine to form the basis for determining the number, size and crown class of seed trees which should be left on cut-over areas in order to reseed the ground.

No further work is planned along this line for the immediate future, but it is a study which should by all means be continued at a later date when opportunity offers.

Sect. (d). Source of Seed.

A comparative study of the growth and behavior of western yellow pine from nineteen different climatic regions, representing comprehensively the entire commercial range of the species in the western United States, has been carried on since the fall of 1911. Ten different lots have been installed since the beginning of the first growing season. Seven more were raised at the Experiment Station Nursery and installed in 1914 and 1915. The last two lots will be ready to plant out in 1917, completing the series. The plantations are in a solid block on a uniform site and consist of from 50 to 100 plants each, spaced 5 X 5 feet.

This is a long time experiment and it is too early to draw definite conclusions. The stock from the Coconino Forest in Arizona, planted in the spring of 1912, has consistently been in the lead in rate of growth. The stock from District One Forests, such as the Coeur d'Alene, is not far behind, however, and is increasing its rate of growth each year, and it is not at all unlikely that it will catch up with and surpass the Arizona stock within a few years.

Since all European investigators along this line consistently advise the use of local seed rather than that taken from a different climatic region, and since our tests show that local seed germinates best in the nursery, and that local stock is on the whole doing about as well or better than

other stock at the end of the fifth season, it seems to be part of conservatism to advise the use of local seed just as far as possible. While it is possible that seed from other regions will prove eventually to be as good, or even better than local seed, it is felt that the burden of proof should be on the introduced seed and that until it has definitely proved itself to be better, the rule should be to use local seed.

A study of the source of seed of Douglas fir similar to that of yellow pine, was started in the fall of 1911 with five lots of stock from different regions. Two more lots were added later in 1913 and 1914. Unfortunately these plantations have all been seriously damaged by a needle disease (Botrytis) which has killed the tender growing tips each season, producing a stunted, bushy plant, which is incapable of making any considerable height growth on a main axis. Comparisons of the growth of such stock are valueless, and it is thought that the damage has been so universal and long continued that it is almost hopeless to expect enough of the stock to recover to make the experiment worth following up.

The principal point of value brought out has been that Douglas fir from the west slope of the Cascades in Washington is not frost hardy at Priest River, and that it is not safe to use stock grown from West Coast seed on the

Forests of District One. Seed from the Wenatchee Forest on the east slope of the Cascades has also shown a slight tendency to frost injury, but this may not continue as the stock grows older.

In the spring of 1916 a report and plan for further work was prepared for the Douglas fir study, summing up the results to date and recommending that the study be discontinued owing to the hopelessly damaged condition of the plantations, the comparative unimportance of the study from a practical standpoint and the fact that the program was already overloaded with more important work.

Plantations of Douglas fir stock from a number of different sources have been made in connection with this project on the Savenac experimental area. The results obtained from these plantations will be of practical application in the planting of Douglas fir on the large burned over areas in the immediate region. The study of the effect of source of seed of Douglas fir from the standpoint of scientific interest is being thoroughly covered by the work being done in District Six and elsewhere, and need not be repeated in this District with that purpose alone in view. It is therefore felt that the plots at Priest River should be discontinued as experiments, and that the work on the study in this District should be limited to the observations of the plantations at Savenac.

A study of the effect of source of seed of western

white pine similar to those for yellow pine and Douglas fir, has been started, with stock raised mostly at Priest River. Stock from two forests has been planted and stock from five other forests is in the nursery and will be planted in 1917 and 1918. The study will be limited to representative points within the commercial range of the species in Montana, Idaho and Washington.

Another study of the source of seed of western white pine is on the program, which has for its object the determination of the relative quantity, fertility and growth behavior of seed collected from individual trees of different size, age and character. For purposes of classification, this study might better be called a study of seed production. The work that has been done to date has included the collection of cones and extraction of seed from a number of trees of different size and crown class on the Coeur d'Alene Forest in 1915. The data obtained has been of much assistance and value in the management studies in the white pine type, in furnishing a guide as to the number, size and character of seed trees which should be left on cut-over areas in order to reseed the ground.

It has definitely demonstrated the seed producing value of small trees below the merchantable diameter limit, which are left in considerable numbers on white pine cuttings, and this information has made it possible to reduce very considerably the number of merchantable seed trees which need to

be left. This in turn has made it possible to reduce the investment in seed trees, increase stumpage returns on sales by an appreciable percent and favor the operator in the logging by giving him more merchantable material and simplifying the problem of brush disposal and removal of logs. Without this information as a basis conservatism would have required the reservation of a considerably larger percent of the merchantable timber for seed trees.

In connection with seed collecting and seed testing work, germination tests have been made in the greenhouse of white pine seed collected from several different ages and kinds of stands. The data obtained so far has been somewhat incomplete, but has served to indicate that seed from 50-year old stands is of excellent quality and that seed from 250-year old stands is also of good quality and compares favorably with that produced by vigorous mature trees of the 140-year class. With this information as a basis, it is felt that seed collecting operations can be safely conducted within a wide range of age classes in the white pine type, varying from half-grown pole stands to over-mature decadent stands.

Sect. (e). Physiological Characteristics and Methods of Stimulating Germination.

This study has been carried on since 1912 with western white pine seed. The tendency of white pine seed to delay its germination in the nursery and to lay over in the seed bed until

the second season, has been a serious problem in nursery practice, and the Station has for the past five years devoted a considerable portion of its time and energy to an attempt to discover some method of obtaining prompt and satisfactory germination of this species.

Between six and seven hundred separate treatments of the seed have been made, using all methods which appeared to have any promise. Stratification treatments have not only failed to increase germination but have proved distinctly harmful. Sawdust is the best medium out of the several which were tried. Treating the seed by moisture and heat treatments combined produced a distinctly stimulating effect, but the increase was not great enough to justify considering these treatments successful. Freezing the seed produced some increase in germination, but was not much better than the heat treatment. Soaking the seed in about a dozen different chemicals showed that treatment with sulphuric acid gave a germination from 4 to $7\frac{1}{2}$ times the check tests, and that several of the other chemicals, including potassium sulphate, acetic acid and potassium permanganate produced distinctly stimulating effects. Mechanical treatment of the seed-coat was by far the most successful method used. Cutting a small hole in the tip of the seed-coat gave excellent results. Removing the seed-coat entirely produced prompt and immediate germination, and demonstrated that the cause of delayed germination was undoubtedly

some quality of the seed-coat which made it impermeable to some necessary substance. This is probably oxygen, since the seed was found to absorb water readily.

Delayed germination has been encountered in Europe in connection with several of the five-needled pines, including western white pine, and an effort has been made to obtain the results of European studies on this problem. Mr. Johannes Rafn, an experienced seed tester of Copenhagen, wrote the Station under date of October 20, 1916, as follows:

"The preparatory treatment of the slowly germinating species, such as *Pinus strobus*, *P. monticola*, *P. Lambertiana*, *Abies Normandica*, is as follows:

The seed is first soaked a day and night in water. After the latter has been poured off and the seed is left to stand in fairly moist condition in a box or jar, until at the end of from one to six weeks, it begins to germinate; it is only then that it is sown out. During those weeks the seed should preferably stand in some sheltered moderately warm place, say under a slate roof. All the time stirred carefully once or twice every day, and it should always be kept in a fairly moist state, yet without standing in water. The boxes containing it are to be covered up with some old sacks and remain so till germination commences."

What is apparently a practical solution of the entire problem of obtaining prompt germination of western white pine seed in the nursery came to light in an experiment to determine whether or not the seed required a period of rest or after-ripening between the time of shedding and time of germination. In the fall of 1915 several lots of cones were hand picked from trees as soon as ripe in early September. The cones were immediately spread out to dry at room temperatures and the seed

extracted by hand within a short time and stored in glass bottles. Germination tests were made in the greenhouse and were also sown in a nursery bed in early November. The greenhouse tests gave very high percents of germination, ranging from 70% to 90%, while the fall sown tests in the nursery germinated 79% and 80% very promptly during the first three warm weeks in May. These tests were thorough enough to show beyond a doubt that the tendency toward delayed germination in this freshly extracted seed was negligible. On the other hand, seed collected on the same Forest at the same time and allowed to remain in the moist cones over winter before extracting, showed the same tendency toward delay in germination as had been found in previous years.

It, therefore, appears that the sluggishness of white pine seed in germination is due not so much to a natural tendency in the seed itself as to the reduction of its vitality, and an alteration in the structure of the seed-coat, brought about by allowing the seed to remain in contact with moisture while stored in the cones prior to extraction. By extracting the seed promptly, using careful methods, and sowing the seed in the fall, no trouble should be experienced in obtaining a satisfactory stand of white pine seedlings in the nursery. It is felt that this problem has been solved sufficiently for practical needs in nursery practice, but there still remain a number of interesting points dealing with the reasons for

delayed germination which should be solved in order to make the study thorough and complete, and in order to bring out fundamental causes and effects which may have far reaching scientific and practical value, particularly in the white pine management studies. A progress report of the work to date will be prepared during the coming year.

2. Nursery Practice.

Sixteen nursery practice studies, or sub-projects have been carried on with four important species --yellow pine, white pine, larch and Douglas fir. The field work in the nursery was done in 1912, 1913 and 1914, with transplant tests in 1915 and 1916 of the stock obtained from the seed bed experiments. All field work on these studies has now been completed and final reports will be issued during the coming year.

Many nursery practice problems are peculiarly of local significance, and for this reason nine out of the sixteen studies carried on at Priest River have had to be continued at Savenac, where the results were to be used, before conclusions for application at Savenac could be drawn. All of the work has served a valuable purpose in providing at least some information for use at Savenac and in working out methods of investigation which have been used in the more comprehensive work later undertaken at ^{the} large Nursery.

Sect. (b). Time of Sowing.

Nursery bed tests with yellow pine, white pine, and western larch, made in 1912 and 1913, clearly indicate that fall sowing is much superior to spring sowing at Priest River (and presumably at Savenac) in furnishing a much larger and more prompt germination and in producing larger, stronger and more uniform plants. The contrast was not so marked with yellow pine as with white pine and larch, but even with the former species the results were conclusive. From the data obtained it is recommended that all white pine and larch sowing be done in the fall. Yellow pine does somewhat better when sown in the fall, but may also be sown in the spring to advantage, when nursery economy makes spring sowing advisable.

Sect. (c). Preliminary Treatment of Seed.

Studies to determine the value of grading white pine and yellow pine seed so as to eliminate small or otherwise undesirable seeds before sowing in the nursery beds were started in the spring of 1915. The working plans were prepared and the grading of the seed was done at the Experiment Station after which the seed was sent to the Savenac Nursery for sowing. The grading was done by means of sieves and a very detailed examination was made of the five different size-classes of seed into which the original lots were graded.

Indications at the end of the second growing season are that the plants grown from the larger class of seed are

distinctly superior in size and development to those grown from the smaller seed. The germination of the smaller seed was, however, just as good or even slightly better in some cases than that of the larger seed. The indications are that it will pay to sift out the smaller seed, but it will require further tests in the transplant beds and in the field before conclusions can be drawn from the experiments.

Sect. (d). Depth of Cover.

Experiments with yellow pine and western larch were conducted in 1913 and repeated for purposes of verification in 1914, testing the comparative value of depths of cover varying from $1/4$ to 1 inch. Stock from the 1914 beds was used for a 2-year test in the transplant beds in order to confirm the conclusions obtained from the seed beds. With both species the shallower depths from $1/4$ to $1/2$ inch made a distinctly better showing than the greater depths, resulting in a larger and more prompt germination, coupled with a smaller loss from damping off, and producing larger and more vigorous seedlings and transplants.

The optimum depth of cover for yellow pine appeared to be $3/8$ inch, although $1/4$ inch and $1/2$ inch depths made almost as good a showing. With western larch $1/4$ inch gave slightly the best results, with $3/8$ inch and $1/2$ inch not far behind. These experiments were all for spring sowing and it is possible that for fall sowing slightly greater depths

will be desirable, although it is thought that these depths may be used with entire safety.

The determination of the correct depth of cover to use in nursery work is of great importance in obtaining a maximum germination and a uniformly good stand of seedlings and in reducing the loss from damping off to a minimum. The results of these two studies have been sufficiently conclusive to be applied at the Savenac Nursery without additional work at the latter place.

Sect. (e). Methods of Sowing.

Studies in comparing broadcast sowing with drill sowing of yellow pine, white pine and larch have shown clearly that broadcast sowing is the best method to use. It produces a larger and more prompt germination than drill sowing and is accompanied by a distinctly smaller loss in damping off. These factors result in a saving of from 10% to 20% in the number of seedlings secured at the end of the season. This, together with the fact that broadcast sowing is accompanied by economy of time, space and expense in the handling of the sowing and covering work in the nursery, fully justifies the present exclusive use of this method at the Savenac Nursery.

Sect. (g). Shading.

Seed bed tests in 1913 and 1914 with yellow pine, larch and Douglas fir, followed by tests for two years in the transplant beds of the stock produced in the seed beds, have

led to the following definite conclusions:

(1) Yellow pine should not be shaded at any time. Shading retards and decreases germination, increases the loss from damping off and produces distinctly inferior, poorly developed seedlings, compared to those produced when the beds are not shaded. Observations at Savenac Nursery confirm these results and shading of yellow pine has been discontinued there since 1914.

(2) Fall sown beds of larch do best when ^{not} shaded, since germination occurs very early in the spring and the seedlings are able to withstand the hot, dry weather of mid-summer and make good growth. Spring sown beds germinate best when not shaded, but half shade should be used during July and August, in order to protect the tender young seedlings from the direct rays of the sun. On the whole, unshaded larch stock produces the best development and greatest survival in the transplant beds.

(3) Spring sown beds of Douglas fir germinate best during the early part of the season when shaded. But a light 1/4th shade should be used during the hot, dry weather of July and August, in order to furnish some protection to the tender seedlings.

The results obtained at Priest River on these studies are considered conclusive enough for use at Savenac without further work at that place. They have led to a con-

siderable reduction in the amount of shading, compared to that used up to 1913. This has meant a material saving in the cost of shade frames and in the time and expense required in handling and storing them.

Sect. (h). Watering.

Seed beds of yellow pine and larch were treated in 1913 and 1914 by three distinctly different methods of watering, as follows:

(1) Cultivated after every rain, with no artificial watering.

(2) Given a total of .75 inch of water per week, including rain, in one application, with cultivation after rains and watering.

(3) Heavily watered with a total of 1.5 inches of water per week, including rain, in two applications, but not cultivated.

The stock raised under these conditions was tested in the transplant beds in 1914 and 1915. These studies have led to the following definite conclusions:

(a) For yellow pine, light watering with cultivation, (Method 2), produces as good or better stock than when twice as much water is given without cultivation, and .75 inch precipitation per week is sufficient for yellow pine, even in a hot, dry season like 1914.

(b) Larch produces best results in the case of the

first two methods--(Cultivation alone and cultivation with light watering). This shows that larch does best with only a moderate amount of water when combined with cultivation.

(c) Both studies indicate that cultivation in drill sown beds is a very favorable method of conserving moisture and producing good stock in small ranger nurseries where water is expensive, or difficult to obtain, or where questions of economy in sowing or nursery work are not primary factors.

Sect. (i). Root Development.

Field tests of yellow pine transplant stock pruned at time of transplanting, and seedling stock pruned in place by cutting off the lower portion of the roots with a spade, have shown a consistent lead both in survival and growth in favor of the pruned stock, in comparison with similar unpruned stock. This clearly shows that a reasonable degree of pruning in the nursery is not only justified by the greater convenience and economy in the transplanting operations, but is preferable to not pruning because it produces a hardier and more vigorous plant by increasing the development of lateral roots.

Sect. (k). Methods of Retarding Spring Growth.

Tests were made with western white pine stock in 1915 to determine the value of attempting to retard spring growth of transplants and field stock, by taking up early in

the spring and storing in the cool, moist sawdust just above the ice in an ice house, with the tops open to the air. This method was suggested by State Forester Griffith of Wisconsin, who said that he had used it successfully and that it enabled him to prolong the transplant season at his nurseries and to also prolong the field planting season well into mid-summer.

The test at Priest River indicated conclusively that this method of storage, while it checks spring growth of the stock, led to very serious deterioration and loss, both in the transplant beds and in the field planting. The stock which was not stored and was allowed to remain in the nursery until ready for transplanting or field planting, in each case produced much better results than any of the lots of stock that had been stored, and those lots which were stored for the longest period of time were decided failures. This would indicate that in cases where it is necessary to do transplanting or field planting late in the spring, it is a safer practice to leave the stock growing in the nursery and take it up when needed rather than to attempt to store it.

3. Sowing and Planting Studies.

The Experiment Station program includes thirty-one out of the thirty-two studies or sub-projects assigned to the District. Of these, fifteen are tests of exotic species and sixteen are tests of classes of stock, seasons, methods and sites. The work at Priest River has comprised something over

200 field plots and includes some 30,000 separate plants or spots, and has involved a large amount of time and expense for experiments, counts and reports. All of these studies, with the exception of a majority of the tests of species and the study of classes of yellow pine and white pine stock, have been completed as far as the field work at Priest River is concerned, and final reports on them will be issued during the coming year.

Sect. (a). Tests of Exotics.

(1) Hardwoods.

Thirty-six field planting plots have been established, including twenty hardwood species. Eighteen more species have been raised in the nursery, but have not been field planted. This will be done during 1917 and 1918 with those species which offer any promise.

The oaks, maples and ashes, particularly those species which are native to the northern tier of states in the Great Lakes region and New England have produced more promising results than any other hardwoods. A majority of the trees that have been tried have shown more or less susceptibility to frost during late August or early September. It is a peculiarity of the climate at Priest River that there is a comparatively sudden drop in temperature at this time of year, which is not found in the climate of the Eastern and Lake States. This early cold weather makes it difficult for most

species to mature their wood in time to resist freezing temperatures, and distinctly limits the number of hardwood species which offer promise of being suitable for the Northern Idaho climate. The tendencies shown to date are summed up in the following lists of promising species, doubtful species and failures:

<u>Promising Species.</u>	<u>Doubtful Species.</u>	<u>Failures.</u>
Red Oak	Yellow Birch	Black Beech
Black Oak	European Beech	Sycamore
White Oak	Basswood	American Beech
Bur Oak	Shagbark Hickory	Babylon Willow
Swamp White Oak	Pignut Hickory	Hackberry
White Ash	Chestnut	Japanese Walnut
Oregon Ash	Black Ash	Yellow Poplar
Black Ash	Butternut	Turkistan Ash
Sycamore Maple	Broadleaf Maple	Tree of Heaven
Soft Maple	Oregon Alder	
Norway Maple	Green Ash	
Box Elder	Chinese Poplar	
White Birch	Spanish Poplar	
Black Cherry		
White Elm		
Hazelnut		

(2) Conifers.

Fifteen species of conifers have been tried. Several

of them show great promise of proving useful species in this region, and have, during the first four or five seasons, made distinctly faster growth than the native species. This is true particularly of eastern white pine, which has grown in some cases several times as fast as the native western white pine. The results of the tests to date are summarized by the following classification:

<u>Promising Species:</u>	<u>Doubtful Species.</u>	<u>Failures.</u>
Eastern white pine	Jeffrey Pine	Loblolly Pine
Scotch Pine	Austrian Pine	
Norway Pine	Siberian Larch	
Norway Spruce	Sugar Pine	
European Larch	Sitka Spruce	
Japanese Larch	Big Tree	
	Incense Cedar	
	Concolor Fir	

In addition to the regular experimental field plots used in these tests, it is planned to set out on the Experiment Station grounds groups or individual specimens of as many species of exotic trees as can be induced by careful treatment to grow at Priest River. The rolling character of the cleared area surrounding the Station buildings and the distinct variations in soil moisture which occur, will offer opportunity to place each species in a situation particularly adapted to its needs. Eventually an interesting arboretum

will be developed at small expense which will be of considerable scientific as well as ornamental value.

Sowing and Planting of Native Species (Sections b,c,d and f).

The different phases of the planting problem are so inter-related that it is impossible to make a thorough study of one without considering all of the others. For instance, seedling stock may be successful or unsuccessful according to the quality of the stock, according to whether it is planted by a careful method or a fast, less careful method, according to whether it is planted early in the spring, late in the spring, or in the fall, or according to whether it is planted on a south slope or a north slope or a flat. Consequently a thorough experiment in age classes must be repeated often enough to test out a wide range of locations, sites, seasons, parts of seasons and methods. Such an experiment must obviously extend over a period of many years even with an abundance of time and the best of facilities. For this reason the conclusions based on the first five years work at Priest River, although reliable as far as they go, must be accepted as only tentative indications, subject to later results from the same experiments and verification or modification on the basis of the results of even more comprehensive experiments being carried on at Savenac and Placer Creek.

It is thought that the results of the work can best be summed up by discussing each phase for all species. For the sake of brevity it will be necessary to omit the details regarding installation and operations and limit the discussion to results secured.

Sect. (b). Age and Size Classes of Stock.

This section has received as much attention as all the others combined because of its great economic importance.

About 100 plots, including about 16,000 plants and seven age-classes,--(1-0, 2-0, 3-0, 1-1, 2-1, 1-2 and 2-2)--on different sites and in different seasons and by different methods have brought out the following information:-

(1) On the basis of survival, two-year-old seedling stock of yellow and white pine may be used on the more favorable sites with an assurance of a good stand and reasonably good growth. On the most severe sites transplants (preferably 1-2) should be used.

(2) Three-year-old transplant stock shows a consistent lead in rate of growth over 1-1 transplants or two-year-old seedlings. One-year yellow pine and white pine seedlings, although they show a good survival in every case, are making very slow growth and are completely outclassed in this respect by the older stock. By developing a more fibrous root system on two-year seedlings by pruning in place, it may be possible to reduce or entirely overcome the advantage in rate of growth

shown by the transplants. Every effort should be made to produce seedling stock of the highest possible quality, as its successful use means a saving of about 90¢ per acre in the cost of planting or a possible \$3,600 on the total of 4000 acres annually planted in the District.

(3) Thorough experiments in the comparison of white pine and yellow pine stock graded into different size classes, have shown a consistently lower survival and rate of growth for the smallest sizes. The contrast varied from almost nothing in the case of white pine on a favorable northeast site, to a difference which, if the smallest 25% had been culled out, would have raised the average survival from 63 to 75, and average current growth from 3.2 to 3.6 inches, in the case of white pine on a medium severe site. Culling of 25% of yellow pine would have raised survival 3% and rate of growth from 4.2 to 4.4 inches. This culling of 25% would have increased the cost of stock about 35 percent and the small advantage in survival and growth does not appear to justify the large increase in cost. Culling is more advisable for severe sites than for favorable sites.

It is doubtful whether the culling of more than 5% of the smallest plants is justified under any circumstances on a financial basis and it is thought that an increase in the quality and uniformity of the stock should make it possible to eliminate even this small amount of culling. Culling of

more than 5 percent appears to be merely throwing away good planting material and increasing the cost of stock needlessly. Caution should be exercised in culling and it should not be done on assumption or guess work, but should be held to a very small percent including only those plants which are very certainly of inferior value by reason of mechanical injury or almost total lack of root or top. Small size alone does not justify culling, provided the plant has a fairly complete and well developed top and root system. The possibility that small size of the plant is a sign of poor growth later should be proven a fact before it is used as the basis of culling. The experiments at Priest River will eventually prove or disprove this point.

Age-class experiments with Douglas fir and larch have not been comprehensive enough to allow of very definite conclusions, but indicate that transplant stock gives a distinctly higher survival and more rapid growth, and that seedling stock, if used at all, should be limited to the most favorable sites.

Sect. (c). Season for Sowing and Planting.

The evidence as to season is to some extent conflicting, due to the many variables in quality of stock, methods of planting, sites, etc. The majority of experiments show tendencies which support the following conclusions:

(a) Fall planting has given best results with larch, white pine and Douglas fir. Early spring planting of yellow pine has made the best showing. However, fall work with yellow pine and early spring planting of white pine and Douglas fir have made a good enough showing to justify planting at that time of year in cases of administrative convenience. Larch should be fall planted.

(b) Spring sowing of yellow pine and Douglas fir and fall sowing of white pine and larch have given distinctly the best results to date.

3. Methods of Sowing and Planting Yellow Pine.

(a) Planting has shown itself in the case of all four species distinctly superior to sowing as a method of establishing a well stocked stand, even on favorable sites. Rodents, insects, drouth, and competition with other plants have all been contributing factors in the lack of success secured in sowing work, particularly by the broadcast and cornplanter methods.

Seed spotting was the most successful method of sowing, giving about two-thirds as high a percent of survival as planting. The cost of seed-spotting is sufficiently close to that of planting, however, to make its use questionable when compared on the basis of cost per surviving plant or successful spot, and the relative completeness of stocking. Unless a very cheap method of seed-spotting can be developed,

it is recommended that planting be used exclusively for yellow pine. The burden of proof should at least be placed on the seed spot method before it is extensively used.

(b) In addition to greater survival, planting shows another important advantage over sowing in a faster rate of growth. This difference in growth tends to increase rather than diminish as the plots become older and if continued may lead to an important difference in the amount of timber produced in a given time on planted and sown areas.

Sect. (f). Sites Suitable for Sowing and Planting.

(a) Only yellow pine 1-2 transplants of the best quality should be used on severe, steep, thin-soiled southerly slopes, at altitudes below 3000 feet. With care in planting such stock will give a survival of better than 50% on the most severe sites.

(b) Douglas fir and yellow pine transplants give good results in survival on southerly aspects of medium steepness, and fair soil. Where the growth of grass and brush on such sites is heavy a serious element of competition is introduced which, when combined with a low percent of soil moisture, is probably one of the principal reasons why the plantations on a site of this kind are growing only 1/5th as fast as those on a flat sandy bench nearby.

(c) Larch is not adapted to southerly slopes at altitudes

below 3000 feet and white pine makes a very poor showing on such sites. Larch does best on well drained sandy benches.

(d) White pine has made a fair showing on a sandy bench but does best on flats with a loam soil and on north slopes. One point brought out is the considerable difference in growth of white pine stock on a steep northeast slope and on a sandy bench. The latter, altho a supposedly poorer site, because of the distinctly lower survival, shows a current growth the second season of 2.4 inches, compared to 1.4 inches for the north slope. Difference in temperature and insulation would account for this.

Summary:

1. Results of Seed Studies.

a. Guiding principles to be followed in the extraction of yellow pine and white pine have been worked out. This has resulted in a great improvement in the quality of seed now obtained, with a corresponding reduction in the amount of seed needed and the expenditures for seed collection.

b. Methods of seed testing have been developed and standardized as the basis for the large amount of testing necessary in connection with nursery sowing and the investigative work on seed studies, sowing and planting studies and management studies.

c. Data has been obtained on the quantity and quality of white pine seed production from representative age classes.

This has proved of great value in the drawing up of marking rules for the white pine type as a guide to the number of seed trees to be left. The results were compiled by Mr. Zon and published in 1914.

d. A comprehensive study of the effect of source of seed of yellow pine upon growth and behavior has been started with stock from nineteen sources. It is too early for definite conclusions. A similar study with Douglas fir has not been successful, owing to disease attacks and will be discontinued. A study of white pine source of seed has been started with seed from different parts of Montana, Idaho and Washington.

e. A study of the fertility of seed from different sizes and ages of individual white pine trees has been started. The information obtained up to date has been of use in the preparation of marking rules for the white pine type in furnishing a guide to the number and size of seed trees that should be left.

f. Investigations of delayed germination of white pine seed have shown that the cause of delay is the impermeability of the testa but that prompt germination is obtained and the tendency to delay becomes a negligible factor if the seed is extracted soon after the collection of cones and is sown at once in the fall. When seed is stored in moist cones for several months the tendency to delay in germination becomes marked. Sulphuric acid treatment; soaking in water, followed

by storage in a warm place in a moist condition; and mechanical cutting or abrasion of the seed-coat, are all more or less effective means of overcoming this tendency toward delay found in seeds that have been improperly stored and extracted.

2. Results of Nursery Practice Studies.

a. Fall sowing is preferable for white pine and larch. Either fall or spring sowing of yellow pine is allowable, but sowing in the fall has made a slightly better showing.

b. Experiments to determine the value of seed grading have been undertaken. The field tests being made at Savenac indicate that small seed is producing distinctly smaller plants than large seed.

c. The optimum depth of cover for yellow pine has been determined to be $3/8$ inch and for larch $1/4$ inch. This information will make it possible to secure maximum germination with minimum loss from damping off, with a resultant economy of seed and seed bed space.

d. Broadcast sowing has been shown to be the best method with yellow pine, white pine and larch, as it produces maximum germination with a minimum loss from damping off and permits economies in nursery management.

e. It has been shown that yellow pine should not be shaded; that larch sown in the fall should receive no shade but that spring sown larch should be given half-shade in July and August; and that Douglas fir should be given $1/4$

shade in July and August, with no shade earlier in the season. This had led to a reduction in the amount of shading done with consequent saving in the cost of frames and expense of handling them.

f. Both yellow pine and larch do better when cultivated and given a moderate amount of water than when heavily watered and not cultivated. This information is of value for use at small Ranger nurseries where cultivation is possible.

g. Pruning of roots at time of transplanting and pruning of the roots of seedling stock while in place, has been shown by field tests to be a desirable practice as it leads to higher survival and better growth in the field, together with economy in transplanting and handling of stock.

h. Retarding of spring growth of white pine stock by storage in an ice house has been proven an undesirable practice. Leaving the stock in the nursery until needed has given better results than storage.

3. Results of sowing and planting Studies.

a. Out of thirty-eight hardwoods tested, sixteen have proved promising, thirteen doubtful and nine ~~are~~ failures. Of the fifteen exotic conifers tested six are promising and show excellent growth, eight are doubtful, and one is a failure.

b. Two-year-old seedling stock of yellow pine and white pine has been proven a success on favorable and medium sites. Three-year-old transplants (1-2) should be used on severe sites.

Two-year-old and three-year-old transplant stock is making better growth than two-year seedlings in fourth and fifth year.

Culling of planting stock is not justified on the basis of small size alone and should be confined to less than 5% of the poorest and weakest plants which are very deficient in top or root.

c. Fall planting appears best for larch, white pine and Douglas fir. Early spring planting of yellow pine has given best results.

Spring sowing is best for yellow pine and Douglas fir, while fall sowing does best with white pine and larch.

d. Planting is the most successful and economical method of establishing a stand of yellow pine, white pine, larch and Douglas fir.

Seed spot sowing is moderately successful but not as desirable as planting.

The rate of growth is more rapid on plantations than on sown plots.

e. On steep severe south slopes yellow pine transplants should be used; on moderate south slopes yellow pine and Douglas fir may be planted; on sandy benches larch does best, also yellow pine; on heavy soiled flats and north slopes white pine is most successful but makes most rapid growth on a level sandy bench.

Conclusion.

The results obtained on the eleven seed studies, sixteen nursery practice studies, and thirty-one sowing and planting studies, included on the Station program, have gone a long way toward solving many of the most important forestation problems with which the District is concerned. Valuable progress has been made all along the line and the work has, on the whole, accomplished the purposes in mind when the Station was established, of placing the forestation work of the District on a foundation of scientific observation as contrasted with the previous basis of uncertainty and guesswork.

Prepared by D. R. Brewster and J. A. Larsen.

RS
ME, D-1,
P. R. E. S.

December 30, 1916.

Progress in Volume, Growth and Yield Studies at Priest River
Experiment Station.

Plan for Permanent Growth and Yield Plots:

On the experimental forest area of 7000 acres established in connection with the Experiment Station as a working ground, a wide and comprehensive range of types, mixtures, age-classes, and sites is found, representing practically all of the important variations characteristic of the Northern Idaho Forests. The presence of a permanent field station here offers an excellent opportunity to secure periodic data on the growth and life history of the various stands by regular measurements of permanent sample growth and yield plots.

It is planned to establish a complete series of these plots representative of every important variation in type, age-class, mixture, and site, thus concentrating a complete study of growth and yield for the forests of the region within this small, intensively managed and carefully protected area. The system of trails planned for the experimental forest will be of important assistance in the establishment and study of these plots.

Operations in 1916:

As a beginning, an examination was made in 1916 of the several temporary yield study plots measured on the

experimental area in 1912 in connection with the western white pine tree study. Five of these plots which fitted well into the general plan, were resurveyed and permanently marked and remeasured in the fall of 1916. The advantage in using these plots lay in being able to compute four years' growth and in tying the work into the previous study of yield.

Results:

A summary of the data from these five plots is given in the following table:-

Summary of Growth and Yield Data Obtained in 1916.

Aspect:	Elevation	Composition of Stand % Formed by Each Species				Age of	Yield per acre	Current Annual Growth per A.		
:	:	W.P.:	W.L.:	Y.P.:	D.F.:	Std.:	Ft. B.M.:	F.B.M.:	% of Yield	
S.W.	3000	2	13	64*	21	43	10,234	745	7.25	
North	2300	89*	5	0	6	51	12,025	1,095	9.10	
North	2500	27*	27	0	56	46	7,342	879	11.95	
South	2500	5	4	6	85*	48	14,112	773	5.45	
West	2300	8	82*	0	3	49	6,982	393	5.65	
Average						47		777	7.88	

Note: *Indicates the type species.

The more complete figures and descriptions will be indicated in the progress report to be issued.

The figures show a remarkably high current growth rate and indicate that the splendid young pole stands which form such a large percent of the stocking of the experimental forest are

growing at the rate of 777 ^{B.M.} Ft. per acre per annum, which will double their board foot volume in less than fifteen years. The plots are representative of all four commercial types found on the ares,--white pine, larch-fir, yellow pine and Douglas fir.

This is the ultimate method of obtaining growth and yield data and it is felt that the start made this year has demonstrated the value of the work and has furnished an additional justification for the maintenance of a permanent field station and experimental forest at Priest River.

Plans for Further Work:

The final complete series should include three plots for each of the principal types, and aspects in the 40-60 year age-class,--one near the foot of the slope, one near the top of the slope, and one about half way between. As much of this work will be done in 1917 as possible, and the balance will be completed as opportunity offers in succeeding seasons. An effort will be made to remeasure in 1917 all of the suitable 1912 plots that remain available, in order to make the first remeasurements at the end of a 5-year period. One month for two men is estimated for the 1917 work.

Prepared by D. R. Brewster and J. A. Larsen.

RS
Mr-1, D-1.

December 30, 1916.

Summary of Results to Date
Study of Factors Affecting Natural Reproduction
Priest River Experiment Station.

The Problem:

Information regarding the germination and establishment of the important native tree species under various conditions of site and environment was urgently needed in the management studies, in order to prove or disprove certain theories in regard to natural reproduction that had been evolved in connection with the study to determine correct silvicultural methods of cutting.

Operation:

In the spring of 1913, seed of the six important native species,--yellow pine, white pine, larch, Douglas fir, hemlock and red cedar,--was sown on three representative sites, a northeast slope in the white pine type, a sandy flat in the larch-Douglas fir type, and a southwest slope of medium severity in the yellow pine type. For the determination of the conditions of the environment, advantage was taken of the nearby presence of meteorological stations which had been established in 1911 for a comparative study of forest types. Seed was sown broadcast in two beds on each site, one

being in the open and the other under the natural shade characteristic of the site. Each bed contained duplicate sowings, one on a burned surface (in the open beds) or a denuded surface (in the shaded beds), and the other on a natural surface covered with grass and other living ground cover characteristic of the site.

Germination and loss counts were made in 1913 and 1914, and the stands of seedlings were thinned out in 1915 so as to allow unrestricted development as a basis for a comparative study of growth.

Results:

The principal information obtained regarding the different species, at the end of the fourth season, is summed up below:

1. Western Yellow Pine.

Yellow pine finds its optimum site on the sandy flat in the larch-fir type. It does well on south slopes, but is unable, on account of excessive moisture, damping off and low temperatures, to hold its own with other species on north slopes. It germinates and survives best and makes its best growth on a burned or denuded surface in the open.

2. Western White Pine.

White pine is best suited to north slopes where it germinates best in the shade on natural surfaces, but shows the best survival and growth on burned mineral soil in the

open. While growth is somewhat better on the flat this is offset by smaller germination. It is unsuited to southwest slopes but does reasonably well on sandy flats.

3. Western Larch.

Larch finds its optimum site on the sandy flat. It is unsuited to south slopes but does well on north slopes. Germination is best in the open and on burned or denuded mineral surfaces. Survival was very low under all conditions, but better in the open and on mineral surfaces than on natural ground cover and in the shade. Drought and damping off caused heavy losses particularly of the considerable germination which occurred the second season, all of which died except that in the shaded bed on the flat.

4. Douglas Fir.

Douglas fir is best suited to the sandy flat. It does well on the northeast slope where it shows excellent survival and good growth. The southwest slope is a rather severe site but permits fair survival with slow growth. Germination, survival and growth is best in the open on burned or denuded mineral soil.

5. Western Hemlock.

Hemlock is much better suited to the northeast slope than the other sites. It shows fair germination and some survival in the shade on the flat, but is a total failure on the southwest slope. Germination is best on natural

surfaces in the shade, but survival is best on mineral soil in the open. Growth is best on natural surface.

6. Western Red Cedar.

Cedar finds optimum conditions on the northeast slope where it shows much the best germination, survival and growth. It does fairly well on the flat, but is almost a total failure on the southwest slope, although one seedling is still alive. Germination, survival and growth are all better on burned or denuded mineral soil than on natural surfaces, and are also better in the shade than in the open.

7. Effect of Living Ground Cover.

It was shown conclusively with all species that the living ground cover was an important factor in competing with the seedlings for soil moisture and root room. This was particularly evident on the southwest slope where more critical soil moisture conditions were encountered than at the other sites, making a severe test of the ability of the different species to withstand drought. The influence of the grass competition is plainly shown here in the much greater number of seedlings of all species surviving on burned or denuded soil compared to those left on natural surfaces.

This information is valuable in showing the desirability of denuding a considerable area of soil in seed spot work and of destroying the ground cover beneath seed trees on cut over areas in the yellow pine and larch-fir

types by brush burning and logging operations.

The natural surface cover also shows a marked tendency to increase loss of seedlings from damping off. This is probably due to (1) the lower vitality of the seedlings, due to competition of other plants; (2) the presence of spores and growing tissues of damping off disease in the duff and litter which comes in contact with the tender seedlings; (3) the greater surface moisture and atmospheric humidity found where there is a living ground cover which favors the fungus growth and permits a more rapid spread of infection than is possible on mineral soil. Hemlock and white pine germinated best on a natural, duff-covered surface, but survival of all species was best on a mineral soil.

8. Effect of Shade:

Shade decreases germination and survival of the intolerant yellow pine, larch and Douglas fir, and checks their growth. Germination of the more tolerant white pine, hemlock and cedar was better in the shade but cedar was the only species which showed best survival in the shade.

9. Delayed Germination.

Although seed was spring sown and was not, therefore, subjected to exactly the same conditions as seed shed naturally from the cones in the fall, the records show the comparative tendencies of the different species toward delay in germination.

Almost as much germination of white pine and larch occurred the second spring as in the first season. Yellow pine and cedar showed a small amount of second season germination, while Douglas fir and hemlock showed none at all.

With all species, there was a very high percentage of loss of second season germination, probably due more to the exceptionally hot, dry period of seven weeks in 1914 than to the fact that it was second year germination, although such seedlings may have had a naturally lower vitality because of the long storage of the seed in the ground.

10. Effect of Damping Off.

In order to determine if possible, the causes of the heavy mortality of seedlings during the first season, cultures were made of a great many of the seedlings and the resulting growths were examined for signs of parasitic fungi. The only kind definitely identified was ^a species of *Rhizoctonia*. Pure cultures were made and used to inoculate healthy seedlings grown in the greenhouse. Fourteen out of a total of sixteen inoculations resulted in death while none of the untreated checks were affected. This was considered reasonable evidence of the parasitism of this fungus and of its primary influence in causing the death of a majority of the seedlings which died from fungus attack in the reproduction plots.

Damping off was particularly prevalent on the northeast slope and did greatest damage on all sites in the shade and on natural surfaces. From these studies it appears to the

most important cause of seedling mortality in stands of reproduction and more destructive than all other causes combined.

11. Effect of Drought.

Drought was an important cause of seedling death on the southwest slope where at times the percent of moisture in the first six inches of soil fell to almost nothing. It was also a minor cause of death on the sandy flat but its influence was probably negligible on the northeast slope. The high mortality of the moisture-loving, tolerant, white pine, hemlock and cedar on the southwest slope was primarily due to drought, including deficiency of both soil moisture and atmospheric humidity. Many seedlings on the southwest slope and sandy flat which survived the attacks of damping off the first season, succumbed to the long seven weeks drought in the exceptionally hot, dry season of 1914.

12. Effect of Frost and Winter-Killing.

There was a surprisingly high over-winter loss of seedlings in many of the plots, particularly on the southwest slope and the sandy flat. Probably a majority of this was due to frost heaving in the late fall and early spring made possible by the melting of the snow blanket on those sites at dangerous seasons. The seedlings on the northeast slope were protected by snow from the first snow in the fall until the last melting of snow in the late spring.

Conclusions:

The information obtained in this study is of considerable value in connection with the management and type studies in explaining the behavior of reproduction of the native species, under closely controlled conditions representative of the three important forest types. The data correlates germination, survival, and rate of growth of seedlings on the three sites with the meteorological and climatic data obtained on the same sites in the study of types. It also serves to check the information obtained in studies of cut-over areas and burns by showing under what conditions germination and establishment of desirable and undesirable species takes place. This furnishes a guide to the proper marking and handling of timber sales to secure the establishment of desirable reproduction.

Plans for Further Work:

The data obtained to date will be assembled during the coming year into a complete final report on the experiments started in 1913.

As soon as opportunity offers, probably in the fall of 1917, it is planned to start some new experiments with a similar purpose in view, but planned along somewhat different lines, to check and amplify the 1913 work. These intensive experiments will be supplemented by examinations of cut-over areas and reproducing burns at every opportunity during the course of the season's field work.

Prepared by D. R. Brewster and J. A. Larsen.

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December 30, 1916.

Study of the Relation of Meteorological Conditions to Fire
Hazard.

Progress at Priest River Experiment Station - 1916.

Operations:

Work on this project was begun during the summer of 1916 in connection with the meteorological study of forest types. Determinations were made weekly of the moisture in the duff and litter and surface soil at three representative points where other climatic readings were taken, viz: (1) In a 50-year-old stand of white pine and Douglas fir on a north-east slope; (2) in an open stand of young yellow pine and Douglas fir on a southwest slope; and (3) in a larch stand on a sandy flat. The dryness and inflammability of the duff was tested at the time of taking each sample by lighting it with a match.

Results:

The percents of surface moisture for each site, during the progress of the dry period have been plotted, together with the principal climatic data, to show the relation of evaporation, precipitation, wind velocity, atmospheric humidity, and air temperature to the dryness of the duff and litter.

The most consistent relationships shown are that decrease in moisture content and increase in inflammability of duff and litter correspond almost exactly with decrease in moisture of surface soil and that the danger point or time of greatest inflammability is coincident with the lowest atmospheric humidity and the period of highest maximum air temperatures. In 1916 this danger point occurred on August 14, 27 days after the last rain of any consequence ($\frac{1}{2}$ inch July 18) and 3 days before the next effective rain. The changing atmospheric conditions preceding the coming of rain caused a marked falling of temperature and rise of humidity on August 15 and 16 although the rain did not start until the 17th.

It was discovered that the duff and litter would not ignite from a match until its moisture content fell below 8 percent. This condition was not reached at any time during the season on the northeast slope but it occurred on the flat and southwest slope 17 days after the last effective rain, ($\frac{1}{2}$ inch on July 18), and continued to decrease for the next ten days after which conditions preceding the storm of August 17 caused it to raise.

Plans for Further Work:

This study is of great value in determining a basis for the prediction of critical forest fire conditions

for different types and slopes. It should be continued in connection with the climatic studies to be carried on at the Station each season and the study should be made more comprehensive by making arrangements for the submission of duff and litter samples from other points in the District where climatic data is being obtained. The data would be of greater value if samples could be taken once a day during the dryest periods as this would show the absolute minimum moisture percents reached prior to rains and would permit of more accurate plotting and comparison of curves. A working plan will be prepared before the beginning of the fire season.

Prepared by D. R. Brewster and J. A. Larsen.

December 30, 1916.

Short Summary of Results of Five Years Work in the
Meteorological Study of Forest Types
Priest River Experiment Station

Operations:

This study was begun in 1911, at the time the Station was established and has been conducted through five growing seasons, the field work being discontinued in the fall of 1916. Its purpose has been the determination of basic factors which control the distribution of forest types, such as climate, soil characteristics, etc.

Observations and instrumental readings have been taken at four year-long stations, one in a white pine-Douglas fir stand on a northeast slope, one in an open young stand of yellow pine and Douglas fir on a southwest slope, one in a stand of larch on a sandy bench, and one in a white pine stand on a flat near the creek. Practically all the data has now been worked up and tabulated or reduced to curves.

Conclusions:

Some of the principal points brought out by the study are given below:

(1) The yellow pine site on a southwest slope has a longer growing season than the other sites.

(2) The factors which favor the presence of yellow pine forest are the longer growing season and warmer air and soil on the southwest slope.

(3) The controlling factors affecting the distribution of white pine and larch are principally soil moisture, soil composition and soil depth. White pine will survive if the soil moisture does not fall below 20 percent as a minimum. Larch will survive if it falls as low as 6 percent. The minimum moisture on Yellow Pine and Douglas fir sites is sometimes as low as 2 percent.

(4) The drying effect of the greater wind velocity and higher temperatures on the southwest slope renders conditions there more critical both for seedlings and from the standpoint of fire danger. These severe conditions tend to exclude all species but yellow pine, lodgepole and Douglas fir.

Final Report:

A final report on this phase of the forest types project will be prepared during the coming year. The report will include not only the specific data obtained at Priest River but will also sum up the climatic data available from Weather Bureau records for the entire District by preparing tables of precipitation, temperature and other factors for the natural climatic units into which the District may be divided. This data will be correlated with the altitudinal and geographic distribution of forest types within the District. The climatic factors which control the distribution of

the important species and types will be worked out for application in reforestation, fire protection and management studies.

Plans for Further Work:

It is recommended that a new study be undertaken at the Experiment Station during the coming season, as a continuation of this same broad project. Its object will be to determine the relation of climatic factors of site such as soil moisture, soil temperature, air temperature, humidity, etc., and physical site factors such as slope, aspect, elevation, etc., to the actual growth and development of the species found on the different sites. Studies of growth of larger trees to be made on the permanent growth plots on the experimental forest will be supplemented by studies of germination and establishment of reproduction made by sowing seed in small plots on the different sites in connection with the natural reproduction study (project Mr-1). The study should be more ecological in character than in the past and should aim to consider the forest type as a unit plant society and include a study of the interrelation of all its component parts and their reaction to the environment. The results will be directly applicable in management studies, as well as in fire protection and reforestation.

It is proposed to continue the study for about five years,--until 1921. A working plan will be prepared before work starts. Estimated cost for 1917 is \$450.00

Prepared by J. A. Larsen.